chamber was closed in each case for half an hour before observations of velocity were made.

Fruit-bodies of fungus	Density of spores	Diameter of spores in μ	Observed terminal velocity in mm. per sec.	Calculated terminal velocity in mm. per sec. for a sphere with density and diameter equal to those observed for the spores	Actual terminal velocity exceeded calculated by a percentage of
Specimen I.	1·02	11·65	6·07	4·14	47
Specimen II.	1·02	10·19	4·85	3·21	51
Specimen III.	1·02	10·87	5·11	3·64	40

From the results just given it is clear that the figures obtained by observation for the rate of fall of the spores are of the same order of magnitude as those demanded by Stokes's law. However, the law is not confirmed in detail, for, as an average of the three experiments, it was found that the actual velocity of fall of the spores was 46 per cent. greater than the calculated. I have not been able to find any satisfactory explanation for the discrepancy between observation and theory.

My method for testing Stokes's law appears to have various advantages over that used by Zeleny and McKeehan, for the following reasons:—Amanitopsis spores have smooth walls, and are practically truly spherical, whereas lycopodium spores have sculptured walls, and are four-sided. Amanitopsis spores have a diameter only one-third as great as lycopodium spores. In the tube method convection currents cannot be eliminated, and it must surely be somewhat difficult to decide the exact centre of the spore clouds. By my method of using a very small chamber the difficulty of convection currents was reduced so as to be negligible, and the velocities of the individual spores could be measured with considerable accuracy. Amanitopsis spores are liberated spontaneously by the fungus, whereas lycopodium powder requires to be set in motion by artificial means.

In conclusion, I wish to thank Prof. J. H. Poynting for permitting me to carry out the experiments here recorded in the physics department of the University of Birmingham, and also Dr. Guy Barlow for valuable criticism.

A. H. REGINALD BULLER.

The Botanical Department, University of Manitoba, Winnipeg, March 25.

Ionisation by Röntgen Rays.

THE relative ionisations produced in different gases by beams of X-rays have been found by many investigators to depend so markedly on the penetrating power of the X-rays used that no regularity in behaviour has been discovered (see Mr. Crowther's paper "On the Passage of Röntgen Rays through Gases and Vapours," Roy. Soc. Proc., January 14).

Recent experiments which I have made upon homogeneous beams have, however, shown the connection between ionisation, secondary radiation, and absorption in a most striking way. As in the case of absorption phenomena (see letter to NATURE, March 5, Barkla and Sadler), a knowledge of the secondary radiation characteristic of an element is essential and sufficient to explain many of the phenomena of ionisation.

In order to test if such a connection existed, the first substance experimented upon was ethyl bromide—a substance which has been investigated in some detail by Mr. Crowther.

By using homogeneous beams of X-rays, I found that all radiations experimented upon which are not more penetrating than the secondary radiation characteristic of bromine (coefficient of absorption in Al = about 50) produce ionisations which are proportional, or at least approximately proportional, to the ionisation produced by the same beams in air.

When the radiation passed through the vapour was made more penetrating than the radiation characteristic of bromine, the ionisation rapidly increased—that is to say, the ratio of the ionisation in ethyl bromide to that in air rapidly rose to several times its original normal value. It was found to be essential to the production of what may be called the abnormal ionisation simply that the primary radiation be more penetrating than the secondary radiation which bromine emits. This result must be connected with the results of experiments on absorption and secondary radiation.

Thus, when an X-radiation incident on a substance R is softer than the secondary radiation characteristic of R, it is absorbed according to a simple law, the absorption being approximately proportional to the absorption in any other substance in which a characteristic radiation is not excited; it produces no appreciable quantity of this secondary radiation, and it produces what may be called a normal ionisation in R. When the incident radiation becomes more penetrating than the secondary radiation characteristic of R, it is absorbed by an amount greater than given by the law stated; it begins to excite the secondary radiation in R, and it produces an increased ionisation in R. The absorption and ionisation increase to several times their previous value, while the intensity of secondary radiation becomes very great.

As the penetrating power of the incident radiation is increased still further, the absorption by R diminishes, and the secondary radiation excited in R diminishes at the same rate as the ionisation produced by the incident radiation in a thin film of air.

(It should be pointed out that the great increase in ionisation is not due to the secondary radiation.)

In a similar manner, from a knowledge of the secondary X-rays emitted by iodine, the variable behaviour of methyl iodide may be explained. The effects of the lighter elements are comparatively small in all the three phenomena of absorption, secondary radiation, and ionisation.

Very many of the apparently complex results, obtained by experiments on the transmission of heterogeneous beams through compound substances, may be explained in terms of a few simple laws which have been obtained by the more fundamental experiments on elementary substances with the use of homogeneous beams.

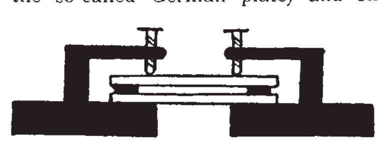
CHARLES G. BARKLA.

University of Liverpool, April 7.

A Simple Fabry and Perot Interferometer.

DURING a course of experiments with interferometers it was found that a very simple and inexpensive Fabry and Perot instrument could be constructed of plate glass which gives results almost as good as the costly interferometer. The construction of this apparatus for demonstration purposes will well repay the teacher and student. The sharp-coloured interference rings obtained by using luminous gases in vacuum tubes as sources are extremely beautiful. The D lines from a sodium burner are easily separable. If the interference pattern, using a copper or iron arc, is focussed on a wide slit of a single-prism spectrometer, a section of the interference rings is seen in the various spectrum lines, illustrating the method of Fabry and Buisson, and Eversheim, for the determination of the new standard table of wave-lengths. The Zeeman effect can also be easily shown with this apparatus.

Take two pieces of plate glass about an inch square (I have used the so-called German plate) and silver[1] them



until one surface of each plate cuts down the intensity of the transmitted light to about a quarter of the incident light. Separate these silvered surfaces by two strips of cardboard. A useful thickness to begin with is about 0·45 mm., as this will clearly separate the D lines. Mount these plates over a half-inch hole in a metal plate by means of three pressure screws, two of which are shown in the above diagram, being a section through

[1] For silvering solutions see the appendix to Baly's "Spectroscopy."

the centre. The third screw is midway between the other two, and at the end of the plates.

Looking normally through the plates at the glowing filament of an incandescent lamp, a number of images of it will probably at first be seen. Adjust the pressure screws until these images are in juxtaposition in the line of sight; the silvered surfaces are then approximately parallel. Place the instrument in a clamp stand, and focus the light from a sodium flame or a vacuum tube upon the plates, and look at the interference bands with a small laboratory telescope focussed for infinity. Usually the eye-piece has too large a magnification for the above retardation, and it is better to use in place of it a single lens of focal length about 2 inches. At first only a small section of the interference pattern is seen, but with a little careful adjustment of the pressure screws the whole ring system is obtained in sharp focus. Removing the telescope, and with the above lens used as eye-piece, focus the interference system from the above sources, or an arc upon the slit of a spectroscope. The bands in the different spectrum lines are thus observed with the telescope on the spectrometer.

For further suggestions regarding the adjustments and other experiments for which this apparatus can be used reference may be made to an article by the writer in the *Philosophical Magazine* for May, 1904.

JAMES BARNES.

Bryn Mawr College, Bryn Mawr, Pennsylvania.

An Ornithological Coincidence.

ON September 18, 1908, a fine, typical male of *Anthus bertheloti*, Bolle, the common Canary Islands pipit, was caught near Cremona, the first of its kind obtained in Italy. I received the interesting specimen "in the flesh." On March 16 of this year Mr. W. P. Pycraft presented at the meeting of the Zoological Society of London an account of the fossilised remains of a small Passerine bird from the "Gabbro" (Lower Pliocene) near Leghorn, which he identified as those of Berthelot's pipit (see NATURE, p. 119). The coincidence is certainly worth noting.

I may add that last autumn, during the later migrations, we had in Italy an unusual inflow of western species of birds, and amongst others and the above-mentioned pipit I received, also "in the flesh," a fine specimen of the large variety of the wheatear (*Saxicola leucorrhoa*, Gm.), known to breed in Greenland and to migrate southwards along the extreme west of Europe into Senegal. The specimen, a female, is the first registered in Italy; it was captured, also near Cremona, on November 7 last.

HENRY H. GIGLIOLI.

Royal Zoological Museum, Florence, March 29.

April Meteors.

MOONLIGHT will not hinder observations of the Lyrids and other shooting stars in the latter part of April in the present year. The following are the principal meteor showers that become due during the period April 19–30. The times of the various meteoric events as calculated by the writer are expressed in Greenwich mean time.

Epoch April 19, 12h. Shower of eighth order of magnitude, the maxima of which occur on April 20, 10h. 45m., 22h. 30m., and April 22, 6h. There is also another smaller shower connected with this having its maxima on April 20, 12h., April 21, 18h., and April 22, 7h.

Epoch April 25, 1h. This shower, which is of the thirteenth order of magnitude, has its principal maximum on April 27, 14h. Secondary maxima take place on April 25, 14h. 30m. and 20h. 30m.

Epoch April 29, 18h. Shower of seventh order of magnitude. Its principal maximum occurs on April 27, 9h. 45m., and there are other maxima on April 27, 23h. 45m., and April 29, 3h.

From the foregoing it seems that meteors should be found especially numerous on the nights of April 20 and 27. On the latter night there are two principal maxima occurring at times very suitable for observation.

April 12. JOHN R. HENRY.

THE GRAMOPHONE AS A PHONAUTOGRAPH.

IT is well known that during the last few years the gramophone (invented by Berliner in 1887), in its more complete and expensive forms, has been so much improved as to have completely eclipsed the phonograph. It is now an instrument that not only records pitch and intensity, but also quality to a surprising degree, so that one can listen to orchestral music in which the quality of each musical instrument is rendered with much fidelity, and also to the fine voices of many of the most celebrated vocalists of the day. Chorus effects are also remarkable, and one can, for example, enjoy the Soldiers' Chorus from *Faust* or the Wedding Chorus from *Lohengrin*. The nasal effects, the thin reediness of the voices, the alterations in quality, so characteristic of the phonograph, and of the gramophone in its earlier stages, have now almost entirely disappeared; indeed, it is no exaggeration to say that no scientific instruments have made greater progress since the inception of the phonograph a little more than thirty years ago.

Certain interesting data regarding the gramophone disk are worth recording. These I have determined on one of the smaller disks having a diameter of $10\frac{1}{2}$ inches, with the record beginning $\frac{1}{4}$ inch from the margin. The record then traces its spiral groove until it is $2\frac{1}{4}$ inches from the centre, so the record has a breadth of a little more than $2\frac{3}{4}$ inches, or, say, 3 inches. The diameter at the beginning of the record is 10 inches, in the middle 7 inches, and at the close of the spiral, towards the centre of the disk, 4 inches. Multiplying each by 3·14 gives the circumference of the circle as 31·4 inches, in the middle 21·98 inches, and in the centre 12·56 inches, or, together, 65·94 inches, giving a mean of 21·98 inches, or, say, 22 inches. There are 100 grooves per inch from the centre towards the circumference; $100 \times 22 = 2200$ inches; the breadth of the record $= 3$ inches; therefore $2200 \times 3 = 6600$ inches; or 550 feet, or 183 yards, is the average length of the record groove. That is to say, in reproducing Waldteufel's waltz, *Estudiantina*, the needle, in 205 seconds, ran over a distance of 550 feet. This gives a rate of 32·2 inches per second. With disks of a larger diameter, the length the groove in a long record may be more than 200 yards.

But when this record was reproduced (it is a remarkably good orchestral record) the disk travelled at the rate of 76 revolutions per minute, or 0·8 second per revolution. At the beginning of the record, therefore, 1 inch was covered in 3/100 second, at the middle in 4/100 second, and at the close of the record in 6/100 second. In other words, the needle traverses a shorter and shorter distance, but in the same time, in passing from the circumference to the centre. Consequently there is no alteration in pitch. It follows also that, given vibrations of the same frequency for a note sounding at the beginning of the record and at the close, the marks of each vibration must be closer together at the centre than at the circumference. Thus, supposing a frequency of 200 per second, there would be about six vibrations in an inch at the beginning (outer circumference) and twelve in an inch at the end of the record (centre). A note of 1000 vibrations per second would have thirty in an inch at the beginning, and sixty in an inch at the close of the record. I was able substantially to verify this by placing the disk under a microscope, with a low power, and counting the number of marks in a lineal inch. This also gives a convenient method of determining the pitch of any note, provided one can count a sufficient number of marks